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This annual report and other NRI materials such as *Abstracts of Funded Research*, the *NRI Program Description*, *NRI Research Highlights*, and *NRI Cover Stories* are available on the NRI home page (*http://www.reeusda.gov/nri*). For more information about the NRI, write or call the National Research Initiative Competitive Grants Program, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, Mail Stop 2241, 1400 Independence Ave., SW, Washington, DC 20250-2241; 202-401-5022; nricgp@reeusda.gov.

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Agriculture

NRI Annual Report: Fiscal Year 2000

National Research Initiative Competitive Grants Program

Cooperative State
Research, Education,
and Extension Service

Competitive Research
Grants and Awards
Management

"Knowledge for Tomorrow's Solutions"

Contents

Message From the NRI Chief Scientist

Dear Colleagues and Interested Parties:

The National Research Initiative (NRI) Competitive Grants Program had a good fiscal year (FY) in 2000, with a funding base of $119 million.

The NRI uses a time-tested competitive peer-review process to award grants to support research in the biological, environmental, physical, or social sciences to solve regional and national problems relevant to agriculture, food, forestry, and the environment. The ultimate goal of the research is to ensure that U.S. agriculture and forestry are sustainable and globally competitive. Competition for NRI research funds is open to researchers at all U.S. academic institutions, federal research agencies, and private and industrial organizations, as well as to individual researchers.

A comprehensive review[1] of the National Research Initiative by the board on Agriculture and Natural Resources of the National Research Council of the National Academy of Sciences, completed near the end of the fiscal year, was highly supportive of the quality of the science funded. The report recommended a number of changes in organization and management, some of which have been initiated and others of which will take some time and resources to implement. Significantly, the reviewers iterated the need for an expanded competitive grants program and recommended that funding be increased to $850 million, which, taking inflation into account, corresponds with the original authorizing language of $500 million.

New programs for FY 2000 were based on reorganization and enhancement of scope. Plant Pathology was incorporated into the program on Biology of Plant-Microbe Associations. Weed Biology and Management were incorporated into the program on Biology of Weedy and Invasive Plants. In addition, Photosynthesis and Respiration, and Nitrogen Fixation and Metabolism, were merged into Agricultural Plant Biochemistry. Epidemiological Approaches for Food Safety became a full and integrated program. The number of research programs thus decreased from 28 to 23.

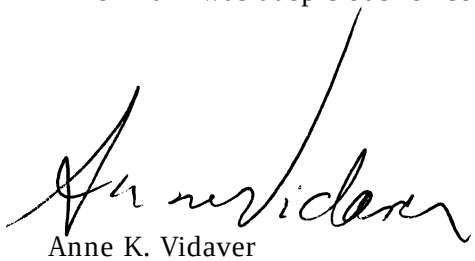
Examples of research supported by the NRI in this report show recognition of important scientific, economic, and sociological questions. A small business, dependent on prior NRI-supported research, is also highlighted. Special recognition is given to Dr. Randall Singer, who received a Presidential Early Career Award for Scientists and Engineers.

[1]National Research Initiative: A Vital Competitive Grants Program in Food, Fiber, and Natural Resources Research. 2000. National Academy Press, Washington, DC, 189 pp.

A significant public effort is already underway and supported with NRI funding in partnership with the National Science Foundation (NSF) and Department of Energy (DOE) – work on the rice genome. Rice has about 430 million letters in its genetic code and is expected to serve as a further model plant for other grains like wheat, corn, barley, and oats, which have genomes that are so large and full of nonfunctioning DNA that they are considered impractical to sequence for the time being. As of September 2000, the federally funded groups have generated 9.4 million of the 26 million bases of rice sequence deposited in GenBank.

The NRI has been remarkably successful, as determined by recognition of the scientists' work, applications to consumers and growers of food and fiber, and use of its findings by new and established businesses. Individuals wishing to learn more about NRI-funded research can do so by reading *NRI Research Highlights*, a series of fact sheets featuring successful NRI-funded research projects and their potential impact on U.S. and world agriculture, and *NRI Cover Stories*, a series of flyers depicting NRI-funded research that has been featured on the covers of prominent peer-reviewed scientific journals. Both are available on the NRI home page (*http://www.reeusda.gov/nri*).

The report that follows is an overview of some of the research the NRI will be supporting over the next 2 to 3 years from its FY 2000 appropriation. I have chosen to highlight just a few of the 683 grants funded. I selected ones that seem to have broad appeal and exemplify USDA's missions. As Chief Scientist, I find it an honor and privilege to be associated with such an exemplary program. I am also impressed with the very capable and dedicated staff, who despite very small numbers do a superb job in administration. I also thank those who support competitive research and the many fine scientists who contribute to the mission of the NRI through their participation in the peer-review process. The start of the millennium was auspicious for competitive research.



Anne K. Vidaver
NRI Chief Scientist

The National Research Initiative: Overview

USDA's National Research Initiative (NRI) was established in 1991 in response to recommendations outlined in *Investing in Research: A Proposal to Strengthen the Agricultural, Food, and Environmental System,* a 1989 report by the National Research Council's (NRC) Board on Agriculture. This publication called for increased funding of high-priority research, funded by USDA through a competitive peer-review process, directed at:

- Increasing the competitiveness of U.S. agriculture.
- Improving human health and well-being through an abundant, safe, and high-quality food supply.
- Sustaining the quality and productivity of the natural resources upon which agriculture depends.

Continued interest in and support of the NRI are reflected in two subsequent NRC reports, *Investing in the National Research Initiative: An Update of the Competitive Grants Program of the U.S. Department of Agriculture,* published in 1994, and *National Research Initiative: A Vital Competitive Grants Program in Food, Fiber, and Natural-Resources Research,* published in 2000.

Competitive Review Process

The NRI competitive review process encourages innovative ideas that are likely to open fundamentally new research approaches to enhancing agriculture, food, forestry, and the environment. A proven mechanism for stimulating new scientific research, the process increases the likelihood that investigations addressing important, relevant topics using well-designed and well-organized experimental plans will be funded. Each year, panels of scientific peers meet to evaluate and recommend proposals based on scientific merit, investigator qualifications, and relevance of the proposed research to U.S. agriculture.

At least 10 percent of NRI funds support Agricultural Research Enhancement Awards. These awards enhance the U.S. agricultural research system through funding of postdoctoral fellowships and research by new investigators, as well as through Strengthening Awards.

Strengthening Awards include Research Career Enhancement Awards, Equipment Grants, Seed Grants, and Strengthening Standard Research Projects. These grants fund researchers at small and mid-sized institutions with limited institutional success or in states and other entities that are part of the Experimental Program for Stimulating Competitive Research (EPSCoR).

The NRI encourages multi-disciplinary research, which is needed to solve complex problems, and seeks to initiate research in new areas of science and engineering that are relevant to agriculture, food, forestry, and the environment. The NRI also supports scientific conferences to facilitate the exchange of information necessary to achieve the most rapid advances in these areas. Both mission-linked research and fundamental research are supported by the NRI. Mission-linked research targets specific problems, needs, or opportunities. Fundamental research – the quest for new knowledge about agriculturally important organisms, processes, systems, or products – opens new directions for mission-linked research. Both mission-linked research and fundamental research are essential to the sustainability of agriculture.

Policy

A Board of Directors, chaired by the USDA Under Secretary for Research, Education, and Economics (REE), provides oversight of NRI policy. Board members include the Administrators of the four agencies comprising the REE Mission Area – the Cooperative State Research, Education, and Extension Service (CSREES); the Agricultural Research Service (ARS); the Economic Research Service (ERS); and the National Agricultural Statistics Service (NASS) – as well as the Deputy Chief for Research of the Forest Service (FS) and the NRI Chief Scientist. The Deputy Administrator of CSREES' Competitive Research Grants and Awards Management Division serves as the Board's Executive Officer.

The Board of Directors oversees NRI policy by providing comments to the CSREES Administrator on the annual *NRI Program Description,* considering the recommendations made by the National Agricultural Research, Extension, Education, and Economics Advisory Board; identifying issues of importance to the NRI; providing a forum on future directions of the NRI; and fostering communication across relevant USDA research agencies regarding NRI programs and procedures.

Identification of Research Priorities

Setting research priorities is an important means of facilitating the scientific and technological advances needed to meet the challenges facing U.S. agriculture. Congress sets the basic budgetary framework for the programs of the NRI by providing funds in six priority categories (see section on Authorization, below). Members of Congress also make recommendations for the scientific and programmatic administration of the NRI through appropriation language and through their questions and comments during Congressional hearings.

Input into the priority-setting process is sought from a variety of NRI customers and stakeholders. The scientific community provides direction for the NRI through the research proposals it submits each year, as well as through the research proposal evaluations and funding recommendations of individual scientific peer-review panels.

NRI scientific staff members play an important role in providing continuity of programmatic and scientific administration from year to year. Staff members attend scientific and professional meetings to stay current on scientific trends that need to be reflected in the *NRI Program Description* and in the coordination of priority setting with other federal agencies. NRI staff also participate in meetings with representatives of key commodity groups and other user groups to discuss these stakeholders' current research priorities, learn ways the NRI can assist in meeting their needs, and solicit comments and suggestions on NRI research priorities.

Input from several coalitions has proved to be an important source of information. NRI staff members meet with groups such as the Institute of Food Technologists, CoFARM, C-FARE, FAIR 2002, and the Animal Agriculture Coalition to gain a broad perspective on current research needs and priorities.

The NRI Chief Scientist, the Deputy Administrator of the Competitive Research Grants and Awards Management unit, and NRI scientific staff are responsible for assimilating the input of diverse stakeholder groups into a program description that will solicit the highest quality proposals to meet the needs of U.S. agriculture. The NRI research areas, which are evaluated and updated each year, are in the annually issued *NRI Program Description*.

The *NRI Program Description* is accessible to universities, federal research laboratories, private research organizations, and individual scientists – both in printed form and on the Internet via the NRI home page (*http://www.reeusda.gov/nri*). In addition, the NRI receives comments on its programs from academic administrators, other staff members, and scientists from universities; the Experiment Station Committee on Policy (ESCOP); and the research administrators of the 1890 land-grant institutions.

Authorization

In the legislation that authorized the establishment of the NRI, Congress defines high-priority research as basic and applied research that focuses on both national and regional research needs (and methods for technology transfer) in the following areas:

- Plant Systems
- Animal Systems
- Nutrition, Food Quality, and Health
- Natural Resources and the Environment
- Engineering, New Products, and Processes
- Markets, Trade, and Policy

The authorizing legislation requires that, as appropriate, grants be consistent with the development of systems of sustainable agriculture. Congress further has specified that no less than 30 percent of funds be used to support multi-disciplinary team research, no less than 40 percent be used for mission-linked research, and no less than 10 percent be used to strengthen the research capacity of individuals and institutions.

Program Implementation

The *NRI Program Description* is distributed widely within the scientific community and among other interested groups. The fiscal year (FY) 2000 *NRI Program Description and Guidelines for Proposal Preparation*, published in the *Federal Register*, identified 23 research programs within the following 8 major research areas:

- Natural Resources and the Environment
- Nutrition, Food Safety, and Health
- Animals

- Biology and Management of Pest and Beneficial Organisms
- Plants
- Markets, Trade, and Rural Development
- Enhancing Value and Use of Agricultural and Forest Products
- Agricultural Systems Research

A total of 2,756 research proposals were considered for funding in FY 2000. Twenty-eight peer panels reviewed and ranked the proposals, evaluating them on scientific merit, the qualifications of proposed project personnel, the adequacy of the proposed facilities, and the relevance of the proposed project to long-range improvements in – and the sustainability of – U.S. agriculture.

Each peer panel was composed of individuals with the expertise required to review each proposal thoroughly and fairly. Proposals for Postdoctoral Fellowships, New Investigator Awards, and Strengthening Standard Research Projects were reviewed within the specified research program area. Proposals for Research Career Enhancement Awards, Equipment Grants, and Seed Grants were reviewed as a group.

Criteria for the selection of panel members included knowledge of the relevant scientific discipline, educational background, experience, and professional stature within the scientific community. The membership of each panel was carefully balanced to reflect diversity in geographical region, type of institution, type of position, and gender and minority status (see Table 1).

Additional expertise was brought to proposal evaluation by a number of scientists and other experts representing a wide variety of fields, who conducted *ad hoc* reviews. These reviews provided the additional expertise that made it possible to select the highest quality, most meritorious proposals for funding.

More than 9,000 scientists contributed their time and expertise to the NRI proposal evaluation process in FY 2000. Participation in the panels and in writing *ad hoc* reviews provided many individuals the opportunity to gain experience in the review process and to become more familiar with the nature of the science supported by the NRI. The pool of *ad hoc* reviewers also provided a resource from which future panel members may be selected.

Table 1. Characteristics of NRI Peer Panels, FY 2000

Geographic Region	Number	Percentage
North Central[1]	87	25.5
Northeast[2]	61	17.9
South[3]	108	31.7
West[4]	85	24.9
Type of Institution		
Land-Grant	220	58.4
Public / Private	55	14.6
Federal	40	10.6
Industry / Other	62	16.4
Type of Position		
Assistant Professor	62	18.2
Associate Professor	102	29.9
Professor	103	30.2
Federal	40	11.7
Industry	16	4.7
Other	18	5.3
Gender / Minority Representation[5]		
Non-minority Males	199	58.4
Non-minority Females	80	23.5
Minority Males	39	11.4
Minority Females	23	6.7

[1] North Central region includes the following states: IA, IN, IL, KS, MI, MO, MN, ND, NE, OH, SD, WI
[2] Northeast region includes the following states plus DC: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT, WV
[3] Southern region includes the following states: AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA
[4] Western region includes the following states: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY
[5] Minorities include Asians, African Americans, Hispanics, Pacific Islanders, and Native Americans

At the conclusion of the review process, a summary of the panel evaluation and the written reviews were forwarded to the submitting investigators, providing them with critical assessments of their proposed research by recognized leaders in appropriate fields. The reviewers' comments and suggestions also were important for refining the proposals for future resubmission.

Continuing a practice begun in 1993, nontechnical summaries describing each research project funded in FY 2000 will be published as *Abstracts of Funded Research* and submitted to the House and Senate Agriculture Appropriations Committees. This publication is also available via the Internet on the NRI home page (*http://www.reeusda.gov/nri*).

Grantsmanship Workshops

NRI program staff conducted a number of workshops in FY 2000 to increase applicants' and administrators' understanding of the philosophy, directives, and procedures of the NRI competitive review process. In FY 2000, staff held a well-attended grant-writing workshop in Orlando, FL, as part of its ongoing practice of conducting a major grant-writing workshop annually in one of the four regions (North Central, Northeast, South, and West) of the United States. The University of Florida hosted the Florida workshop. It focused on guidelines for preparing proposals, individual program descriptions, and recent funding statistics.

In addition, the NRI staff conducted individualized workshops or made presentations at national meetings of scientific and/or professional societies, to regional research groups, and to other audiences, including the Institute of Food Technologists, Council of Undergraduate Research, and national EPSCoR meeting. Other workshop sites included EPSCoR institutions; 1890 land-grant institutions, including Ft. Valley State, Georgia; Hispanic-serving institutions; and tribal colleges.

Funded Research

In FY 2000, a total of 2,756 proposals were submitted to the NRI, requesting a total of $702,360,998 in funding, an amount higher than in previous years. Awards totaling $110,126,103 were made to the highest ranked 683 proposals submitted to the NRI (see Table 2).

The success rate (in terms of number of proposals funded and excluding conferences, supplements, and continuing increments of the same grant) was 26.7 percent, which is 2 percent higher than in FY 1999. The average grant award for new standard research projects (excluding Research Career Enhancement Awards, Equipment Grants, Seed Grants, conferences, continuing increments, and supplements) in FY 2000 was $180,473 for 2.4 years. (For FY 1999, the comparable figures were $165,224 for 2.2 years.)

The NRI provided funds totaling $288,265 in partial support of 32 conferences in FY 2000. These conferences brought scientists together to identify research needs, update one another on research information, and/or advance an area of research important to U.S. agriculture.

In FY 2000, the NRI provided funds totaling $19,134,653 in Agricultural Research Enhancement Awards. This support included Postdoctoral Fellowships, New Investigator Awards, and Strengthening Awards (see Table 3).

Crosscutting Areas

A number of research topics of major importance to USDA involve several research areas or programs. NRI support for these crosscutting program areas in FY 2000 is indicated in Table 4.

The data show the total amount of funding from all research areas for a specified research topic. For example, the Water Quality area includes projects from the Watershed Processes and Water Resources Program, as well as projects from other programs relevant to water quality such as Soils and Soil Biology. The Integrated Pest Management area includes projects funded from the programs on Biologically Based Pest Management; Entomology and Nematology; Biology of Plant-Microbe Associations; and Biology of Weedy and Invasive Plants. The $6.7 million funding allocation for sustainable agriculture represents projects identified from many NRI programs, including the Agricultural Systems Research Program, that are directly relevant to sustainable agriculture. This figure is probably an underestimate since, in a broad sense, all research supported by the NRI is germane to sustainable agriculture.

Table 2. NRI Funding Allocations,[1] FY2000

Research Area / Program	Number of Grants	Total Dollars Awarded
Natural Resources & Environment		
Plant Responses to the Environment	23	$3,452,000
Ecosystem Science	22	4,482,000
Watershed Processes and Water Resources	19	4,118,500
Soils and Soil Biology	21	4,074,500
Totals	**85**	**$16,127,000**
Nutrition, Food Safety & Health		
Improving Human Nutrition for Optimal Health	30	5,110,746
Food Safety	24	4,715,611
Epidemiological Approaches to Food Safety	5	4,056,374
Totals	**59**	**$13,882,731**
Animals		
Animal Reproductive Efficiency[2]	28	4,259,974
Animal Health and Well-Being[3]	63	12,347,515
Animal Genome and Genetic Mechanisms	19	5,614,480
Animal Growth, Development, and Nutrient Utilization[4]	23	3,707,974
Totals	**133**	**$25,929,943**
Pest Biology and Management		
Entomology and Nematology	39	6,430,000
Biology of Plant-Microbe Associations	28	3,830,990
Biologically Based Pest Management	16	2,502,000
Biology of Weedy and Invasive Plants	19	3,029,366
Totals	**102**	**$15,792,356**
Plants		
Plant Genome	24	4,692,075
Plant Genetic Mechanisms	28	4,479,704
Plant Growth and Development[5]	37	4,562,220
Agricultural Plant Biochemistry	26	3,589,800
Totals	**115**	**$17,323,799**
Markets, Trade & Rural Development		
Markets and Trade	23	2,217,000
Rural Development[6]	17	
1,695,500		
Totals	**40**	**$3,912,500**
Enhancing Value and Use of Agricultural and Forest Products		
Food Characterization / Process / Product Research	26	3,820,680
Non-Food Characterization / Process / Product Research[7]	19	2,610,632
Improved Utilization of Wood and Wood Fiber	21	2,532,172
Totals	**66**	**$8,963,484**
Crosscutting and Inter-Agency Programs		
Agricultural Systems	8	2,417,144
Strengthening Programs[8]	71	3,377,145
Metabolic Engineering Program-Interagency[9]	2	400,001
U.S. Rice Genome Project - Interagency	2	2,000,000
Totals	**83**	**$8,194,290**
Awards to Be Determined[10]		**$1,354,679**
Grand Total	**683**	**$111,480,782**

[1]The content of this table varies slightly from tables provided in documents supporting the President's budget to Congress each year in the following ways:1) while the documents supporting the President's budget include data only for funds from the 2000 appropriation, this table includes data on all awards from proposals submitted to the 2000 proposal cycle, regardless of the source of funds (as noted in the table) and 2) awards are arranged in this table under program area (to which proposals are submitted and reviewed) as opposed to relationship to appropriated budgetary lines.
[2]Includes 2 awards funded in whole or part with $20,275 from the FY1996 appropriation.
[3]Includes 1 award funded in whole from $45,875 from the FY1996, $27 from the FY1997 appropriation, $136,566 from the FY1998 appropriation, and $2,532 from the FY1999 appropriation; 2 awards funded in whole or part with $169,200 from the FY1999 appropriation.
[4]Includes 1 award funded in part with $3,152 from the FY1996 appropriation.
[5]Includes 5 awards funded in whole or part with $3,152 from the FY1996 appropriation.
[6]Includes 1 award funded in part with $1,013 from the FY1996 appropriation and $6,922 from the FY1999 appropriation.
[7]Includes 1 award funded in whole with $140,000 from the FY1999 appropriation.
[8] Included 10 awards funded in whole or part from: $38,798.82 from the FY1996 appropriation, $3,581.11 from the FY1997 appropriation, $68,228 from the FY1998 appropriation, $45,414 from the FY1999 appropriation.
[9]Funded entirely from the FY1999 appropriation.
[10]As of November 27, 2000.

Table 3. Agricultural Research Enhancement Awards, FY 2000

Type	Number of Grants	Total Dollars Awarded
Postdoctoral Fellowships	33	$2,960,861
New Investigator Awards	37	5,773,089
Strengthening Awards		
Research Career Enhancement Awards	3	293,774
Equipment Grants	35	943,605
Seed Grants	33	2,139,766
Standard Strengthening Research Projects	52	7,023,558

Table 4. Crosscutting Program Areas, FY 2000

Research Topic	Number of Grants	Total Dollars Awarded
Plant Genome	45	$9,880,090
Forest Biology	25	3,785,542
Global Change	47	7,678,844
Sustainable Agriculture	37	6,762,885
Animal Genome	19	5,614,480
Animal Health	83	16,756,237
Water Quality	33	4,159,881
Food Safety	41	9,156,802
Integrated Pest Management	5	10,170,648
Animal Waste	7	1,030,250

Research Dimensions

As noted earlier, research programs can be examined from perspectives such as type of investigation (fundamental or mission-linked) and organization of research approach (single discipline or multi-disciplinary).

- The NRI defines *fundamental research* as that which tests scientific hypotheses and provides basic knowledge that allows advances in applied research and from which major conceptual breakthroughs are expected to occur.
- In contrast, *mission-linked research* is that which focuses on specifically identified agricultural problems which, through a continuum of efforts, provides information and technology that may be transferred to users and may relate to a product, practice, or process.
- *Multi-disciplinary research* is defined as work on which investigators from two or more disciplines are collaborating closely. These collaborations, where appropriate, may integrate the biological, physical, chemical, or social sciences. NRI funding in FY 2000 for these categories is shown in Table 5.

Table 5. Dimensions of NRI Research, FY 2000

Dimension	Amount of Support	Percent
Fundamental	$47,840,879	43.4
Mission-linked	62,285,224	56.6
Multi-disciplinary	42,085,460	38.2
Single discipline	68,040,643	61.8

Interagency Research

NRI program directors work closely with their research-funding counterparts in other federal agencies to avoid duplication and maximize interagency cooperation. An example of cooperation is seen in the research that NRI funds jointly with other federal agencies, including:

- The Interagency Metabolic Engineering Program, established in 1998 with the Department of Energy (DOE), the National Science Foundation (NSF), the Department of Commerce (DOC), the Department of Defense (DOD), the Environmental Protection Agency (EPA), and the National Aeronautics and Space Administration (NASA).
- The *Arabidopsis thaliana* Genome Sequencing Project, established in 1995 with NSF and DOE.
- The U.S. Rice Genome Sequencing Project, established in 1999 with NSF and DOE.

Each collaborative research program issues a single request for proposals, and agency representatives work together to assemble a panel of scientific peers to identify the most meritorious proposals. From this group, representatives of each agency select proposals that are the most germane to the mission of that agency. Thus, the NRI is able to attract researchers from a wide applicant pool to projects of importance to agriculture.

The National Research Initiative: Achievements

In FY 2000, the NRI funded 683 grants. This section provides examples of fundamental and mission-linked research targeted at problems important to the USDA mission, funded through the 28 panels and related to the 5 broad outcomes outlined in CSREES' *Government Performance and Results Act Strategic Plan*.

Outcome 1: An agricultural production system that is highly competitive in the global economy

Gene Discovery and Regulation. Disease resistance genes in plants code for proteins that recognize the presence of pathogens and then induce defense responses. Transfer of disease resistance genes to crop species from close relatives is a common breeding tool. It is limited, however, by the lack of donor species that can be hybridized with any given crop species, and by the extent of genetic variation in these species that has not already been used. A future trend may be to transfer genes from much more distantly related species by recombinant DNA techniques (engineering). More than 20 plant disease resistance genes have now been characterized at the molecular level. As a result, resistance genes have become easier to isolate. Experimental transfers of resistance genes between close relatives in the tomato family have indicated that some resistance genes will function after transfer to a different species, provided that the species is related.

Dr. Steve Hulbert and colleagues at Kansas State University will determine whether resistance genes will function after transfer between cereal species. They have genetically characterized two genes in maize (corn) for this purpose. The *Rxo* gene confers a defense reaction to the rice bacterial streak pathogen, *Xanthomonas oryzae* pv. *oryzicola*. The *Rpa* gene confers a hypersensitive (resistant) reaction to the sorghum bacterial stripe pathogen, *Pseudomonas andropogonis*. Candidate DNA sequences (gene fragments) that code for these genes will be isolated from maize. Evidence that they code for these resistances will be by reintroduction into maize. Then, they will begin to engineer them into rice and sorghum to determine if they can control these diseases.

Post-transcriptional gene silencing (PTGS) is a fundamental regulatory mechanism operating in plants, animals, and fungi. PTGS serves as an antiviral defense mechanism in plants and may play a similar role in other organisms. Dr. Vicki B. Vance of the University of South Carolina has identified a plant virus protein, the helper component-proteinase (HC-Pro) of potyviruses, that suppresses PTGS and thereby acts as a counter-defense. Another newly discovered protein can also suppress PTGS. She will use these proteins to dissect the mechanism of silencing. The investigation of suppressors of PTGS is highly practical because these proteins have significant potential to improve yield in technologies that use plants to express foreign gene products. Given the antiviral nature of gene silencing in plants and the indications that PTGS is an ancient mechanism in eukaryotic organisms, the work could lead to development of antiviral strategies in both plants and animals.

Plant Cell Wall Synthesis. Physical and biochemical methods to identify mutations in the model plant *Arabidopsis* have rarely been used simultaneously to analyze cell wall composition and architecture. Dr. Nicholas Carpita of Purdue University will use Fourier transform infrared microspectroscopy to analyze mutants with changes in wall cellulose or to the pectin gel matrix surrounding it. Applications in the future include increased shelf life of fruits and vegetables, and improvement of yield and quality of fibers.

Chromosome Maintenance With Telomeres in Chickens. The enormous contribution of poultry to the competitiveness and profitability of U.S. agriculture dictates the need for a more complete understanding of the genomes of poultry species. The chicken is especially important because of the size of the U.S. commercial broiler and layer industries, and because it serves as a model for other commercially important poultry species. Knowledge of the structure, function, and stability of the chicken genome is essential for continued progress in traditional commercial breeding by selection of superior genotypes and purposes of genome manipulation, an area that is likely to be important for future advances. Telomeres are the specialized ends of linear chromosomes and are maintained by the enzyme telomerase. The dynamics of telomere length and telomerase activity directly impact

genome stability by playing a critical role in cellular proliferation, senescence, and oncogenic (cancerous) transformation.

Dr. Mary E. Delany, University of California, Davis, will map the location of particular telomere sequences within the chicken genome, characterize the RNA and protein components of chicken telomerase, and investigate telomerase expression and function in maintaining telomere length in tissues derived from embryos and adults. The research will provide fundamental information regarding a critical genomic region that impacts differentiation, growth, aging, and oncogenesis. The results will improve our understanding of the structure, organization, and function of the chicken genome and will contribute useful information for the selection of genomes for commercial purposes and biotechnology applications.

Biological Sterilization Technique for Cattle. Each year, 13 million beef heifers enter feedlots throughout the U.S. for feeding and finishing before slaughter. However, about 15 percent of these heifers enter the feedlots pregnant, resulting in inefficient use of feed and other problems associated with the unintended pregnancies that are estimated to cost the beef cattle industry $250 million annually. The current approach to prevention of pregnancy in these animals, when used, is to surgically spay them. Not only is this approach costly and time consuming, but it can also have major deleterious side effects upon an animal's health and well-being.

To find an alternative solution to this problem, Drs. Jerry Reeves and Kevin Bertrand at Washington State University are using cutting-edge techniques in molecular biology to develop a vaccine that will neutralize one of the reproductive hormones in cattle. The vaccinated animal develops antibodies against its own hormone, which then prevents the hormone's specific action within the body. The desired result is sterility. If successful, this type of vaccine will be beneficial for sterilizing bull calves, as well as heifers, and would prevent the need for surgical spaying or castration, the use of abortive agents, and the problems associated with difficult calving in feedlot heifers. Such a vaccine could be administered quickly and inexpensively by producers, would improve animal growth and nutrient use, and would markedly enhance animal health and well-being while ameliorating animal welfare concerns about the use of surgical castration. Potential application of this technology would have implications across a broad range of livestock and poultry industries.

Aquaculture in the Gulf of Mexico. Human-made activities in a watershed can have significant impacts on the ecology of downstream coastal environments. The Suwannee River drains 28,500 square kilometers of southern Georgia and north-central Florida. Surface runoff and groundwater inputs contribute high levels of nutrients to this blackwater river before it discharges into the region of the Gulf of Mexico known as the Big Bend. The Big Bend is extensively harvested for oysters and is the site of a newly emergent aquatic agriculture industry, clam aquaculture. The growth and stability of this industry hinges on maintaining a balance between the nutrients that contribute to productivity and excessive eutrophication that can lead to destructive phenomena like blooms of harmful algae and bacteria.

The primary goal of the project, led by Dr. Edward J. Phlips at the University of Florida, is to define the relationship between coastal eutrophication and the productivity of clams and oysters. A clear understanding of this linkage forms the basis for evaluating the consequences of future trends in loading to the watershed. It is essential that a clear understanding of the relationship between cultural eutrophication and the ecology of these important marine resources be developed to ensure the future viability and growth of these aquatic agricultural industries.

Genomic Sequence Analysis of Bacterial Pathogens. Several bacteria cause significant economic losses to production animal agriculture in the United States. Genomic sequencing provides the most direct and cost-effective approach to understanding how these bacteria cause disease as well as laying the foundation for the discovery of novel prevention and treatment strategies against the diseases caused by these microorganisms.

Dr. Stanley Maloy and colleagues at the University of Illinois will sequence the genomes of three strains of Salmonella that cause significant disease

in animals and that also present a risk to human health. These include *S. pullorum*, which causes disease in birds; *S. dublin*, which causes disease in cattle; and *S. choleraesuis*, which causes disease in swine. Drs. Sarah Highlander and George Weinstock from the Baylor College of Medicine will sequence the genome of *Pasteurella haemolytica*, which is of primary importance in shipping fever pneumonia in cattle. Even with years of research, shipping fever remains one of the most costly bacterial diseases in all of production agriculture in the U.S. These projects are the first critical step towards the development of more effective disease control strategies, including new vaccines, diagnostic tests, and antimicrobial agents.

Molecular Genetics of an Important Insect Pest. The Hessian fly is the most important insect pest of wheat. Hessian fly resistance genes in wheat provide an effective method of Hessian fly control and lessen the need for tillage. However, the effectiveness of each resistance gene has a limited duration. Through the action of specific avirulence genes in the Hessian fly genome, Hessian fly populations eventually adapt to overcome resistance, limiting the useful life of each resistance gene to a period of about 8 years. To extend the period of usefulness, researchers need to understand how Hessian fly avirulence genes function.

Dr. Jeffrey J. Stuart, of Purdue University, has found an avirulence gene, *vH13*, which allows Hessian flies to overcome the resistance conferred by resistance gene *H13* in wheat. Chromosome cloning will be performed to identify the avirulence gene and mutations in it that correlate with overcoming resistance. This will be the first avirulence gene cloned and sequenced from an insect. The findings will provide useful information relevant to other avirulence genes in the Hessian fly and other plant-insect interactions.

Carbon Dioxide Incorporation Into Seed. These examples illustrate how basic reach in plant biochemistry may lead to important biotechnology advances for American agriculture. Projects by Drs. Thomas Okita and Gerald Edwards of Washington State University and Drs. Michael Giroux and Luther Talbert of Montana State University address a key question in plant biology. What limits the ability of a plant to take carbon dioxide out of the air and convert it into agriculturally important products in seeds? Okita and Edwards have shown that plants have the ability to fix a lot more carbon than is normally converted into carbohydrates (starch) in seeds. Photosynthesis does not limit yield; the limitation is in those steps that move the carbohydrate to the seed and convert it into starch.

The researchers addressed this by creating transgenic rice and *Arabidopsis* plants whose seeds have greater capacity for converting carbohydrate in seeds to starch. These plants fixed more CO_2 into carbohydrates as a result and yielded more. They will undertake experiments to understand the mechanisms by which this happens and make more transgenic model plants to see if they can further increase the capacity for carbohydrate accumulation in seeds. Giroux and Talbert will determine if the laboratory results generated by Okita and Edwards translate into increased yields in the field. They will use wheat lines with the same transgenic modification engineered by Okita and Edwards to see if these plants show higher photosynthetic rates under field conditions, elevated carbon fixation, and increased yield. Should the laboratory results translate into yield increase in the field, this research could result in a method for substantially modifying yields of all grain crops.

Soil Microbial Communities Affect Tree Establishment. Establishment of an orchard on a site previously planted to apple often results in poor growth and death of new apple trees – a phenomenon termed apple replant disease. The disease is commonly controlled through the application of pre-plant soil fumigants, including methyl bromide. The impending ban on use of methyl bromide and potential regulatory restrictions on other broad-spectrum fumigants place in doubt the long-term availability of suitable chemical measures for control of replant disease. All soil ecosystems possess microorganisms with the ability to control plant diseases. Enhancing populations and activity of these organisms has the potential to serve as an environmentally sensitive and biologically sustainable means to control soilborne plant pathogens.

Preliminary studies demonstrated that cultivating replant soils with wheat selects for a population of microorganisms that can suppress the fungal patho-

gens that cause apple replant disease. This finding is dependent on specific wheat cultivars and was not induced by other grasses. Disease suppression appears to be due, in part, to selection of specific bacteria belonging to the fluorescent *Pseudomonas* spp.

Drs. M. Mazzola and J. P. Mattheis of the ARS Tree Fruits Research Lab, Wenatchee, WA, will identify the fluorescent *Pseudomonas* genotypes that contribute to suppression of apple replant disease and determine the plant traits that are key in the selection of these suppressive bacteria. This information will be significant for identifying wheat cultivars with a superior ability to select for microbial communities that enhance apple growth on replant sites. These studies may also provide the framework for selection of apple rootstocks that support pathogen-suppressive fluorescent pseudomonad genotypes.

Outcome 2: A safe and secure food and fiber system

Food Safety Epidemiology: The Source of the Problem. Feedlots are considered as one of the sources of the human pathogen *Escherichia coli (E. coli)* 0157:H7. Control of this bacterium in the beef industry will require a focused effort from all segments of the industry, including at the farm level. A study by Dr. Janice M. Sargeant, Kansas State University, will determine the extent to which specific management practices affect fecal shedding of *E. coli* in feedlot cattle. The goal of this project is to identify particular management practices that are associated with *E. coli* in order to design on-farm control programs. More importantly, this grant will also look at the effect of these particular management practices on the average daily gain and feed efficiency. This study combines research on food safety and cattle performance.

In a different approach to prevention and control of *E. coli* 0157:H7, Dr. David R. Smith at the University of Nebraska has developed a method to test pens of cattle rather than individual cattle for the prevalence of foodborne organisms. This approach will reduce cost, time, and labor for the producer. Once the prevalence has been determined, then a method of control can help reduce the potential that these pathogens will leave the feedlot. The University of Nebraska has identified a pen-testing protocol that could be a monitoring tool for feedlot production HACCP programs for hazard control and prevention, and a research tool to identify and test potential HACCP control points. This study will validate the pen-test for *E. coli* and *Salmonella* shedding, determine what a positive (or negative) pen test means in terms of length of time cattle may be shedding, and identify potential control points using risk factor analyses.

Ensuring the Safety of Minimally Processed Fruits and Vegetables. Researchers at the University of California, Berkeley, in collaboration with the University of California, Davis, will document the extent to which the survival of pathogenic strains of *E. coli* and *Salmonella* on lettuce leaves is dependent on the numbers of indigenous bacteria present on a leaf. Dr. Steven Lindow and colleagues will also study the role of bacterial aggregates in the survival and proliferation of such pathogenic strains. The results of this study could lead to a more directed approach to identifying inhibitory or competitive indigenous microflora for biological control of bacterial human pathogens on plant surfaces.

In the past few years, several outbreaks of foodborne illness have been traced to unpasteurized fruit juices. A research team at the University of Florida led by Dr. Renee Goodrich will evaluate fruit surface microflora of juice oranges commercially used for production of unpasteurized juices. They will evaluate the internal microbial ecology of the fruit and juice obtained from those fruit and investigate the potential infiltration of microorganisms into the interior of the citrus fruit and effect of such infiltration on juice microflora. This information will provide deeper understanding of the food safety risks associated with fresh and minimally processed citrus fruit products.

Fighting Contaminants of Cheese Factories. The bacterium *Lactococcus lactis* is essential for making American-type cheeses – mostly cheddar. These products have a yearly wholesale U.S. market value of more than $5.6 billion. The most persistent and costly problem in cheese factories is viral (bacteriophage) infections of *L. lactis*, which kill the bacteria and ruin the cheese. Viruses that attack and kill *L. lactis* are natural contaminants of milk and

cheese factory equipment. Traditional methods of isolating virus-resistant strains by natural selection have not solved the problem.

Researchers at Oregon State University, led by Dr. Bruce L. Geller, will investigate specific molecular events that initiate virus infection of the host bacterium, *L. lactis*. The long-term goal is to create virus-resistant strains of *L. lactis*. The researchers have developed a strategy of genetically engineering *L. lactis* that inhibits virus infection. The strategy involves deleting one gene from the bacterium. Without this gene, viruses do not recognize *L. lactis* as a host because the engineered bacterium lacks an attachment site on its surface required for virus infection. Fortunately, deleting this gene causes no change in the growth or metabolic characteristics of *L. lactis*. Therefore, the strategy of deleting this gene to make virus-resistant strains is a practical solution to part of the problem. The researchers plan to extend the understanding of the virus infection cycle in order to rationally design additional applications for overcoming the virus problem in cheese factories.

A Non-Invasive Method for Predicting Safety and Quality of Foods. Food safety is critically important to highly perishable smoked and cured foods produced in the United States. Market demand is for lower salt products. Lower salt concentrations increase the food safety risk. Smoked and cured seafood products are a multi-billion-dollar industry in the U.S. International demand is growing for U.S. cured and smoked aquatic foods, from both the wild fishery and aquaculture. Customers are placing stringent demands on the microbiological safety of these foods. Better ways of assuring good process control during manufacture are needed. Salt is added for the unique flavor and texture characteristic of caviars and smoked fish, and also to control harmful bacteria. However, a less than optimal number of food safety tests are conducted during or after production because of the high cost of lost product from sampling and the long time required for currently available tests.

Scientists at Washington State University, led by Dr. Barbara A. Rasco, are developing a method using a special type of infrared spectrometer. This instrument can measure both the water content and salt content in intact food items. A rapid test, particularly for salt, which would not require product destruction during testing would be an important development.

Johne's Disease: A Cattle Disease Affecting Animal Health and Meat Availability. Accurate detection of animals infected with Johne's disease and effective vaccines against this bacterial pathogen are urgently needed to halt the cattle industry's multi-million-dollar annual losses. This is also a pathogen that has been implicated as a possible cause of intestinal disease in humans. In FY 2000, there was a three-pronged attack against this scourge of cattle producers:

- ***A Major Advance: Exposing the Adversary's Complete Genetic Code.*** In a monumental step forward, researchers at the University of Minnesota, in collaboration with the National Animal Disease Center, led by Dr. Vivek Kapur, will determine the complete DNA sequence for *Mycobacterium paratuberculosis*, the causal agent of the disease. All data will be deposited in public databases so that the entire research community may quickly access this organism's entire genetic blueprint. This investment will significantly accelerate research on questions relating to virulence, pathogenicity, antimicrobial agents, and the identification of antigens that can be used as diagnostic reagents or vaccines.

- ***Developing Better Diagnostic Tests and Effective Vaccines.*** A research team at the University of Wisconsin, led by Dr. Michael Collins, will study the response of five strains of *M. paratuberculosis* under five different culture conditions to express proteins that can serve as diagnostic markers and/or vaccine candidates. A second team at the University of Notre Dame, led by Dr. Jeffrey Schorey, will characterize a number of mycobacterial antigens that result in a cellular immune response first in mice (experimental model), and then in cattle. These antigens are likely candidates for vaccines or diagnostic markers to better detect infected cattle.

- ***Understanding Survival in the Environment.*** Little is known about how Johne's disease survives or persists in the environment. Other mycobacterial species can form clumps (biofilms) believed to help them survive better under defi-

cient growth conditions, temperature changes, and chemical treatment. Scientists at Montana State University, led by Dr. Luanne Hall-Stoodley, will study the ability of *M. paratuberculosis* to form biofilms. Probes will also be developed to help monitor and track the organism's presence in the environment. Expected outcomes include: a better understanding of this organism's survival in the environment, including water supplies; better ways to detect Johne's disease in the environment; and, possibly, improved ways to decrease the organism's spread.

Outcome 3: A healthy, well-nourished population

'Junk Food' and Nutrition in the Diets of American Adults. According to the Department's 1996 Healthy Eating Index, a measure of how Americans' diets fare in meeting the recommendations of the Dietary Guidelines, only 12 percent of Americans have diets that can be classified as "good" – while 71 percent have diets that are considered to "need improvement" and 17 percent are classified as having "poor" diets.

Dr. Ashima Kant of Queens College of the City University of New York, using data from the Third National Health and Nutrition Examination Survey (NHANES III), has looked at intakes of energy-dense, nutrient-poor (EDNP) foods by American adults. She has also studied the association of consumption of these foods with body mass index (BMI). She found that more than one-fourth of total daily energy intake by adults came from EDNP foods, with an additional 4 percent of energy coming from alcohol. Sweeteners and desserts accounted for almost 20 percent of daily energy intake. With increasing intake of EDNP foods, the odds of meeting Recommended Dietary Intake Levels of vitamins A, C, B_6, folate, B_{12}, calcium, and iron decreased. However, the relative risk of having a high BMI, adjusted for age, sex, and race, was not different among the three tertiles of EDNP intake. The results suggest that EDNP foods are consumed at the expense of more nutrient-dense foods, and that additional guidance is needed to show Americans how to moderate their intake of these foods. Dr. Kant has received additional funding to conduct a similar analysis using data from children.

Omega-3 Fatty Acids: Too Much of a Good Thing? Because studies have found that consumption of omega-3 fatty acids is associated with a decreased risk for cardiovascular disease, some nutritionists are recommending that Americans increase their dietary intake of these polyunsaturated fatty acids. These are found in fish in large amounts and in a variety of vegetable sources in smaller amounts. However, little is known about possible deleterious effects of increasing the level of omega-3 fatty acids in the diet.

Dr. Kevin Fritsche of the University of Missouri, Columbia, has found that mice consuming a diet high in omega-3 fatty acids have impaired resistance to the foodborne pathogen *Listeria monocytogenes*. In a continuation of this work, Dr. Fritsche will determine if early exposure to omega-3 fatty acids will have a prolonged impact on the immune response throughout the life span. He will also use strains of mice with selected gene deletions (i.e., knock-out mice) to clarify which components of the immune response are affected by omega-3 fatty acid intake. Results of this research will be of use in determining recommendations for omega-3 fatty acids for humans.

Improved Understanding of B-Vitamin Status. Many elderly persons in the U.S. are at high risk of developing vitamin B_{12} deficiency because they do not absorb the vitamin. Currently, vitamin B_{12} absorption is rarely tested. The only available test uses radioactivity, and it is expensive and impractical. Researchers at the University of California, Davis, led by Dr. Lindsay H. Allen, are developing and validating a new test that can diagnose malabsorption of vitamin B_{12}. The new test proposes to measure vitamin B_{12} absorption by giving a small oral dose of the vitamin and assessing the subsequent increase in the amount of vitamin B_{12} bound to its binding protein (holotranscobalamin II, or holoTC II) in serum.

When dietary folate, a B-vitamin, is inadequate, a large number of health problems associated with abnormal cell division and function may occur, including anemia, impaired growth, and birth defects. In a significant percentage of the U.S. population (12 percent), a genetic mutation occurs, resulting in a change in one of the major enzyme proteins (methyltetrahydrofolate reductase or

MTHFR) required to convert folate to the form most frequently used. Researchers at the University of Florida, led by Dr. Lynn Bailey, are addressing the question of whether women of reproductive age with this genetic defect require a higher dietary intake of folate. The study will provide data related to the effect of the MTHFR mutation on folate requirements of women of reproductive age.

Adequate vitamin B_6 nutrition is essential for optimal health, and poor vitamin B_6 status is associated with increased risk of cardiovascular disease. Researchers at the University of Florida, headed by Dr. Jesse Gregory III, are using non-radioactive (stable) isotopic tracers to determine the functional effects of marginal deficiency of vitamin B_6 on the primary pathways governing homocysteine levels in normal human subjects and rats. These studies will expand our understanding of the functional consequences of vitamin B_6 inadequacy and will yield important new information regarding nutritional effects on homocysteine metabolism and risk for development of cardiovascular disease.

Cataract Prevention. Cataracts affect at least half of the older adult population, and cataract surgery accounts for the largest line item in the Medicare budget. It has been estimated that finding a means to delay the onset of cataracts by 10 years would reduce by half the number of cataract extractions required.

Dr. Allen Taylor of the USDA Jean Mayer Human Nutrition Research Center on Aging at Tufts University examined and photographed the eye lenses of 603 nurses enrolled in the Nurses Health Study in 1993 and again in 1998. This population was used because dietary intake data, measured several times for each participant, was available for the period before their enrollment in the vision study, so that the participants' knowledge of their lens status would not affect their dietary behavior.

Cataract can be found in three locations in the lens: the oldest tissue in the center or nucleus; the cortex, which radiates out from the nucleus; and the youngest tissue in the epithelial layer. Dr. Taylor found that women who were in the highest quintile of dietary intake for vitamin C, vitamin E, riboflavin, folate, alpha-carotene, and lutein/zeaxanthin had a significantly lower prevalence of nuclear cataract than those in the lowest quintile of nutrient intake. After adjustment of other nutrients, vitamin C remained significantly associated with prevalence of nuclear cataract. Prevalence of nuclear cataract was significantly lower for women who used a vitamin C supplement for more than 10 years, relative to women who never used vitamin C supplements. An intake of about 200 mg vitamin C per day was found to give the maximum benefit.

Osteoporosis. Osteoporosis is a public health problem that affects 28 million Americans, 80 percent of whom are women. Drs. Karl Insogna of Yale University and Jane Kerstetter of the University of Connecticut have found that when adult women consume the Recommended Dietary Allowance (RDA) for protein (0.8 g/kg body weight) along with the old RDA for calcium (800 mg), intestinal absorption of calcium is impaired, leading to secondary hyperparathyroidism and loss of bone mass.

According to USDA dietary survey data, about one-third of white women consume protein intakes at or below the level of the RDA, putting them at risk for impaired calcium metabolism. In a continuation of their work, the investigators will now determine if this effect still occurs when calcium intake is raised to the new RDA (1,000 mg). They will also determine if the effects of dietary protein differ when a mixed diet (protein from animal and vegetable sources) versus a vegetarian diet (vegetable protein sources only) are fed. The results of this research can be used to refine dietary recommendations for protein and calcium for women.

Outcome 4: Greater harmony between agriculture and the environment

Crop Production in Sheltered Fields. Shelterbelts, which are rows of trees planted along one side of an agricultural field, may improve crop production, reduce wind erosion, decrease movement of fertilizers and pesticides, create habitat for wildlife and beneficial insects, sequester carbon, and increase economic returns. Although shelterbelts have been used successfully for centuries in other parts of the world, U.S. farmers are reluctant to try them due to insufficient site-specific evidence that their benefits exceed their costs.

Dr. Carl Mize and colleagues at Iowa State University and the University of Nebraska have received a renewal award to further pursue the development of a modeling system to estimate site-specific effects, benefits, and costs for corn- and soybean-producing sheltered fields in the Corn Belt. The long-term goal of this research is to provide farmers with information about the benefits of using a particular kind of shelterbelt in their fields, given the climatic conditions and soil types found there. Over time, increased use of shelterbelts will provide benefits to farmers, consumers, and the environment, ensuring sustainability of agriculture in the United States.

Rising CO_2 and Carbon Sequestration. As the amount of CO_2 in the Earth's atmosphere continues to rise, research on carbon sequestration is becoming essential. In grazing land soils, much of the carbon exists as soil carbonate ($CaCO_3$). Soil carbonate is a potential sink for atmospheric CO_2. Drs. Hugh Monger and Jeffrey Herrick at New Mexico State University are studying CO_2 emissions from the dissolution of soil carbonate (e.g., as a result of acidic rain or microbial actions) in an effort to curtail CO_2 losses from carbonates and promote carbon sequestration in the grazing lands.

In a related study, Drs. Serita Frey and Johan Six at Ohio State University are investigating the microbial contributions to carbon sequestration in non-tilled agroecosystems. They will examine interactions among microbial community structure, soil properties, and the stabilization of microbial-derived soil organic matter. The long-term goal is to maintain soil fertility while developing sustainable agricultural systems that mitigate rising atmospheric CO_2 concentrations through carbon sequestration.

Understanding Wetland Ecosystems. Wetlands have enormous ecological, environmental, and economic value, due to their capacity to assimilate nutrients, provide habitat, and control flood and storm waters. Although recognized for their importance, much remains to be known about how wetlands respond to changes in land use and nutrient enrichment. Many researchers have taken an ecosystem approach to studying these systems.

Dr. Patrick Bohlen and colleagues at Archbold Biological Station in Florida are studying the influence of cattle grazing and land use on freshwater wetlands in rangeland ecosystems. Results from this work will enhance our understanding of nutrient retention in these systems and provide valuable information for the effective management of wetland ecosystems exposed to grazing livestock. In another wetlands project, Drs. Joan Ehrenfeld and Peter Jaffe at Rutgers University are examining the interactions of roots and nitrogen in controlling the redox chemistry of riparian wetlands. They hypothesize that sediment chemistry will vary with the interactions between the nitrogen and the roots. Results are expected to provide information for using riparian wetlands to remove agricultural pollutants.

Increasing demand for freshwater by agriculture, cities, and industry has led to damming of rivers, resulting in decreased freshwater flow to coastal wetlands, and a subsequent decline in productivity and diversity of plants, algae, and plankton. Dr. James Heilman and colleagues at Texas A&M University are studying the effects of fluctuating freshwater inflow on ecosystem productivity and structure of coastal wetlands. Information generated by this study will help lay the groundwork to optimize water use to sustain both agriculture and the coastal environment.

Improving Sustainability of Aquaculture. Aquaculture is an ecologically efficient means of providing seafood for American consumers, but it is limited by a finite supply of water and by pollutants from untreated fish farm effluents. Dr. David Brume of Clemson University and colleagues have developed an innovative new technology, the Partitioned Aquaculture System (PAS), to reduce the environmental impact of aquaculture while increasing productivity and profitability. The PAS system is expected to increase fish production sixfold over existing pond aquaculture and reduce the need for expensive feeds and electricity, while recovering waste nitrogen and phosphorus, which are a pollutant threat to surface and groundwater supplies.

Reducing Tall Fescue Toxicosis in Cattle. Tall fescue, the predominant forage throughout much of the Southeastern and lower Midwestern U.S., is largely infected with an endophytic fungus that improves fescue persistence under adverse conditions. However, this fungus is suspected of causing

fescue toxicosis, a problem that costs U.S. livestock producers about $800 million annually. Dr. Kenneth Coffey and colleagues at the University of Arkansas will improve sustainability of cattle operations in this region by determining forage management practices needed to give non-infected, but less persistent, forages a competitive advantage. These practices are expected to improve animal production and economic returns over time.

Nutrient Use Related to Nutrient Excretion Into the Environment. One of the most important issues facing animal agriculture is management of manure nutrients. A better understanding of how dietary and microbial proteins are digested and absorbed will lead to reduced manure nutrient (i.e., excess nitrogen) load released into the environment, optimization of nutrient use for animal production, and lower costs of feedstuffs to producers.

Nutrient utilization by animals is a function of nutrient transport and metabolism by epithelial cells lining the intestine. These epithelial cells contain specialized proteins called "transporters" that move amino acids and peptides into the cell to be metabolized. Two proposals were funded to further study the function and regulation of amino acids and peptide transporters in cattle and chickens. The proposed studies with cattle by Dr. Joanne Knapp, of the University of Vermont, will focus on: (1) identifying the specific transporters that are found in the small intestine and in a continuous cell culture from cells of the intestine, (2) determining if expression of these transporters changes in response to diet, and (3) determining if expression and activity of transporters changes in response to amino acids and peptides.

The proposed studies with chickens by Dr. Eric Wong of the Virginia Polytechnic Institute & State University will focus on: (1) basic studies of transport kinetics and substrate specificity of a cloned peptide transporter and (2) investigating the developmental and nutritional changes in expression of this peptide transporter in the intestine of chickens.

Can Cattle Be Used in Restoring Ecosystems? A project at the University of California, Davis, by Dr. Karen D. Holl on the role of cattle grazing in conserving grassland biodiversity will investigate the potential for using cattle to restore and manage grassland ecosystems and their associated annual wildflowers. Coastal prairie management using livestock has the unusual and promising potential for meeting short- and long-term needs for agricultural production and maintaining biological diversity.

Outcome 5: Enhanced opportunities for farmers, ranchers, and rural people and ccommunities

Alternative Carbon Sequestering Policies Analysis. Soil carbon (C) sequestration can reduce the level of atmospheric carbon dioxide, a greenhouse gas. Changes in agricultural land use and management practices can sequester C in agricultural soils and could reduce U.S. emissions significantly.

But there is little information regarding what it would cost to sequester C in agricultural soils. Unresolved questions include the baseline level of soil C against which changes can be measured, the consequences of targeting payments to a range of producers, and the "net carbon balance" resulting from altered practices. Each of these issues affects the amount of incentives required to induce producers to participate in such a program. A study on policy design and implications for agricultural soil carbon sequestration, by Drs. John Antle, Susan Capalbo, and Sian Mooney of Montana State University, Bozeman, is designed to address these questions by examining the impacts of alternative carbon sequestering policies on cropping patterns and management practices and net returns. This information will permit the examination of the economic efficiency of alternative carbon sequestering policies.

Americans Eat Poorly...Why? Relative to people in other developed nations, Americans eat poorly. Poor diets and resulting health conditions cost the U.S. economy between $5.1 and $10.6 billion annually. The U.S. Department of Agriculture's dietary guidelines and the National Cancer Institute (NCI) of the National Institutes of Health both recommended an increase in fruit and vegetable consumption in order to help stem these increasing health costs by reducing the incidence of cancer, heart diseases, obesity, and stroke. Even with national campaigns to increase the consumption of fruits and vegetables, such as NCI's 5-a-Day campaign, consumption of these foods remain flat and below levels in other developed countries, even countries that have

similar cultural and economic conditions, such as Canada. Why is this the case?

A study entitled "Bilateral Comparison of Fresh Fruit and Vegetable Consumption: Why Do Americans Eat Poorly" by Drs. Timothy Richards, Paul Patterson, and Jeffrey Hampl of Arizona State University, Mesa, aims to help answer this question. The goal of the study is to identify those factors that influence the consumption of fruits and vegetables. The data will provide scientifically based information to guide policy makers in how to best target future promotion campaigns to increase the consumption of these desirable foods.

Job Training and Productivity in Rural America. Drs. Gary Green and Anna Haines at the University of Wisconsin are examining the quality of job training by employers, the constraints they face, and whether the presence of vocational and technical post-secondary school training institutions has an impact on the quality of training offered by employers. Job training is considered one of the most important factors affecting the productivity of the workforce. In order to understand the impacts on rural development better, it is necessary to identify the constraints to employer job training in rural areas. Six case studies of community-based organizations offering training programs will be conducted and the level and type of training offered in these settings will be evaluated. An assessment will be undertaken to determine the effectiveness of these workforce development networks in addressing the job training problems in rural areas.

Saving Agricultural Land. Hundreds of jurisdictions across the United States are actively seeking to preserve agricultural land and open space. One method employed by many of these jurisdictions deals with the purchase of development rights (PDR) to these lands, thereby precluding development. More than $1 billion has been spent by these jurisdictions in the past two decades. The question being addressed by Dr. Joshua Duke at the University of Delaware is the willingness of farmers to participate in a PDR program. Another question is whether or not the land at most risk for conversion is being enrolled in such programs, which would provide timely information to perhaps adjust PDR policies and programs to target higher risk parcels. While the study will be conducted in Delaware, it has great applicability nationwide.

Deregulation of Electric Utilities in Rural Areas. Historically, electric utilities have been regulated monopolies. In recent years, the utility industry has been deregulated at the federal level and increasingly at the state level. For example, a number of years ago, California deregulated its electric utilities, and last year wholesale costs of electricity paid by retail electric distributors increased fivefold. Electric deregulation has significantly changed the institutional structure and market dynamics by which electricity is delivered in rural states with sparse populations.

The purpose of a study by Dr. Rebecca Richards of the University of Montana, Missoula, is to identify the barriers and opportunities of electric deregulation for rural development, especially for the rural electric cooperatives that serve 32 million people in 46 states. In Montana and the neighboring states served by the state's electric cooperatives, low population density poses particular challenges to serving consumers over an immense area.

The objectives of this proposal are to determine the barriers and opportunities that rural electric cooperatives face in continuing, or expanding energy delivery in the region, the opportunities and strategies that the cooperatives use to maintain or expand utility and telecommunications services, and the services that they provide – or fail to provide – toward local community development needs. Findings from the project will provide a basis upon which to further explore deregulation issues and provide more complete information to energy policy makers.

Pulp and Paper: Impacts on Rural Poverty and Rural Development. Drs. Connor Bailey, Mark Dubois, and Peter Sinclair of Auburn University are examining the impacts of new investments in the pulp and paper sector upon poverty in nearby areas. Using the concept of commodity analysis to explore how the pulp and paper sector is integrated into larger political and economic networks, they are addressing these linkages, questions of resource dependency, poverty, and power. Commodity system analysis has proven a useful conceptual tool

for understanding the organization of production and the existence of linkages (local to global) between an industry's input suppliers, consumers, and other interested parties.

The pulp and paper sector in Alabama is characterized as a producer-driven commodity system where a few large integrated firms dominate the production and value-added processes. Systematic examination of the power inherent in this industry's domination of economic relationships and its network of alliances will contribute to a greater understanding of processes associated with resource dependency generally, timber dependency in the South in particular, and how the defined relationships impact upon rural economic development efforts.

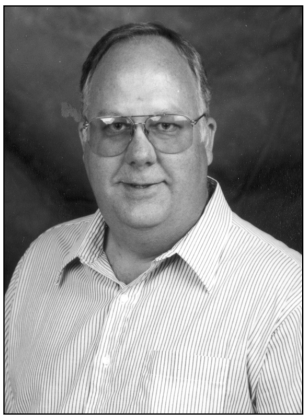
Transitions from Conventional to Organic Farming. Demand for organically produced foods is steadily increasing, and future demand appears assured. However, up to 3 years are required to make the transition from conventional production to a certified organic system. Net farm income may drop during this transition period, and producers thus may be reluctant to make the change due to short-term risks involved. Research at the West Virginia University by Dr. James B. Kotcon will compare two farming systems for making the transition from conventional to organic production. Data from this project will provide producers interested in converting to organic practices a reliable basis for choosing among transition practices in order to overcome traditional barriers to transition, while maximizing productivity and sustainability of their production systems.

President's Early Career Award for Scientists and Engineers

Dr. Randall S. Singer of the University of Illinois, Urbana-Champaign, was the FY 2000 recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE). He was nominated by the NRI for the current and potential future excellence of his research. He received funding for a problem of great national and international interest – the epidemiology and ecology of antibiotic resistance determinants on dairy farms. As a result of the PECASE award, Dr. Singer's grant is extended to 5 years, enabling him to concentrate fully on his research program during this critical phase of his career.

Dr. Singer's work will determine antibiotic resistance profiles of beneficial or neutral bacteria (commensals) and pathogenic bacteria in six dairies over time to assess changes in antibiotic resistance profiles and factors influencing them; identify the bacterial genes at a molecular level to determine their prevalence, similarity, and potential for transfer (gene flow); and develop quantitative sampling methods for monitoring antimicrobial resistance on dairy farms. Bacterial samples from four genera will be cultured from milk and feces. The research is expected to enable prediction of the spread and persistence of resistance genes and lead to intervention points for managing such resistance.

From Discovery to Practice: A Success Story From the Competitive Grants Program (CRGO/NRI) of the United States Department of Agriculture



Discovery research can lead to useful products. Basic research on understanding sperm-associated proteins and their role in fertility of bulls led to specific products that are being used commercially. Using results developed under NRI funding, ReproTec, Inc. applied for and received research and development assistance from the USDA's Small Business Innovation Research (SBIR) Program. One of SBIR's objectives is to increase private sector commercialization of innovations derived from USDA-supported research.

Dr. Roy Ax, Professor and Head of the Department of Animal Sciences, University of Arizona, Tucson, received support from the NRI to work on heparin-binding proteins and fertility of bulls. Specific monoclonal antibodies were developed to identify sperm from high-fertility bulls. The antibody-based detection system was licensed to ReproTec, Inc., of Tucson, and is offered commercially worldwide to pre-screen bulls for fertility potential. The next phase of development is for a new antibody based on a novel fertility-associated antigen. Fertility testing is anticipated to be lower in cost and time-effective (on-site versus sending a sample to a laboratory for testing).

Appendix
Organizational Structure